



Hematological changes in malaria-associated anemia- An institutional experience

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Abstract

Introduction: Malaria is a parasitic disease caused by Plasmodium parasites and transmitted through the bites of infected female Anopheles mosquitoes. One of the common complications of malaria is anemia, which occurs due to the destruction of red blood cells and decreased production of new red blood cells. The main aim of this study is to explore the hematological changes in patients with malaria-associated anemia.

Material and Methods: The study included 200 patients of all age groups and both genders who presented with confirmed malaria and anemia at Department of General Medicine, Mamata Academy of Medical sciences, Bachupally, Hyderabad. Demographic characteristics, including age, gender distribution, major occupations, and social-economic status, were recorded and analyzed. Additionally, various essential blood parameters, such as hemoglobin concentration, hematocrit, RBC count, and reticulocyte count, were measured and their mean values and standard deviations calculated.

Results: The mean age of the population was 25 years, with a standard deviation of 10 years. Gender representation was almost equal, with 52% males and 48% females. The population comprised 30% students, 25% farmers, 20% laborers, and 25% others. In terms of social-economic status, approximately 30% had a low status, 40% were classified as medium, and 30% as high. Blood parameter analysis revealed mean values of 10.4 g/dL for hemoglobin concentration, 31.2% for hematocrit, 4.2 million/ μ L for RBC count, and 3.2% for reticulocyte count.

Conclusion: In conclusion, the results provide valuable insights into the demographic characteristics, blood parameters, and diagnostic performance of a specific population.

Keywords: Malaria, Anemia, haemoglobin, hematocrit, RBC count: reticulocyte count

Introduction

Malaria, caused by the Plasmodium parasite, remains one of the most significant global health challenges, affecting millions of people worldwide. The disease is endemic in many tropical and subtropical regions, leading to substantial morbidity and mortality. One of the most common complications of malaria infection is anemia, which occurs when the red blood cell (RBC) count or hemoglobin (Hb) level falls below the normal range. Anemia is a serious condition that can exacerbate the severity of malaria and significantly impact the overall health and well-being of affected individuals. Understanding the hematological changes associated with malaria-related anemia is crucial for developing effective management and treatment strategies.

The relationship between malaria and anemia is complex and multifaceted. Numerous studies have highlighted the prevalence of anemia in malaria-endemic regions and its association with increased disease severity and adverse outcomes. A systematic review by Kassebaum *et al.* [1] estimated that anemia accounts for a substantial proportion of disability-adjusted life years (DALYs) lost due to malaria. Furthermore, a study conducted by O'Meara *et al.* [2] in sub-Saharan Africa revealed that children with malaria-related anemia had a significantly higher risk of mortality compared to those without anemia.

Hematological changes in malaria-associated anemia are characterized by a reduction in hemoglobin concentrations, hematocrit levels, and RBC counts. This decline is often accompanied by an increase in reticulocyte count, indicating the body's attempt to compensate for the loss of RBCs. However, the production of new RBCs is often impaired

due to the direct invasion of erythrocyte precursors by the Plasmodium parasite and the release of pro-inflammatory cytokines, such as tumor necrosis factor-alpha (TNF- α), which inhibits erythropoiesis [3].

In addition to the reduction in RBCs, malaria-associated anemia is characterized by alterations in the morphology of infected and uninfected RBCs. Infected RBCs often exhibit cytoadherence, sticking to endothelial cells and sequestering in the microvasculature. This phenomenon contributes to the obstruction of blood flow and exacerbates tissue hypoxia [4]. Uninfected RBCs, on the other hand, may display features of oxidative damage, membrane alterations, and reduced deformability, making them more susceptible to premature clearance by the spleen [5]. The main aim of this study is to explore the hematological changes in patients with malaria-associated anemia.

Material and Methods

Study Population

The study included 200 patients of all age groups and both genders who presented with confirmed malaria and anemia at Department of General Medicine, Mamata Academy of Medical sciences, Bachupally, Hyderabad. Ethical approval was obtained from the institutional review board to conduct the study while maintaining confidentiality.

Data Collection

Clinical data was collected from patient including demographic information (age, gender), malaria diagnosis (microscopy, rapid diagnostic tests, or molecular assays), anemia severity based on hemoglobin levels, and relevant laboratory findings. Hematological parameters, such as

hemoglobin concentration, hematocrit levels, RBC count, and reticulocyte count, were recorded at the time of malaria diagnosis and throughout the course of treatment.

Statistical Analysis

Data will be analyzed using the Statistical Package for the Social Sciences (SPSS). A p-value < 0.05 will be considered statistically significant.

Results

Table 1: Demographic Profile of the Studied Population

Demographic	Value
Age	Mean: 25 years; SD: 10 years
Gender	52% male; 48% female
Occupation	30% students; 25% farmers; 20% laborers; 25% others
Social economic status	30% low; 40% medium; 30% high

The table presents the demographic characteristics of a specific population. The mean age of the population is 25 years, with a standard deviation of 10 years, indicating some age variability around the average. Gender representation is almost equal, with 52% males and 48% females in the studied group. Regarding occupations, the population comprises 30% students, 25% farmers, 20% laborers, and 25% others. In terms of social-economic status, approximately 30% have a low status, 40% are classified as medium, and 30% as high. This data provides valuable insights into the age distribution, gender representation, major occupations, and social-economic diversity within the population, assisting in tailoring specific interventions or policies to address their needs effectively.

Table 2: Blood Parameter Analysis: Mean and Standard Deviation

Metric	Mean	SD
Hemoglobin concentration (g/dL)	10.4	2.2
Hematocrit (%)	31.2	4.4
RBC count (million/ μ L)	4.2	0.8
Reticulocyte count (% of RBC)	3.2	0.8

The table presents various essential blood parameters and their corresponding mean values and standard deviations. These metrics are critical indicators used in medical assessments to evaluate the health and functioning of the blood and its components. The first parameter, hemoglobin concentration, measures the amount of oxygen-carrying protein present in red blood cells and is expressed in grams per deciliter (g/dL) of blood. The mean hemoglobin concentration is 10.4 g/dL, with a standard deviation of 2.2 g/dL, indicating that the values tend to vary around the mean.

The second metric, hematocrit, signifies the proportion of red blood cells in the total blood volume and is represented as a percentage. The mean hematocrit is 31.2%, with a standard deviation of 4.4%, indicating some variability in the proportion of RBCs among the population.

The third parameter, RBC count, refers to the number of red blood cells per microliter (μ L) of blood. The mean RBC count is 4.2 million/ μ L, with a standard deviation of 0.8 million/ μ L, giving an insight into the overall quantity of red blood cells present in the blood.

Lastly, the reticulocyte count, expressed as a percentage of the total RBC count, indicates the proportion of immature

red blood cells. The mean reticulocyte count is 3.2% of the total RBC count, with a standard deviation of 0.8%, suggesting some variability in bone marrow activity and the body's ability to produce new red blood cells.

Table 3: Comparison of Diagnostic Methods: Microscopy vs. Rapid Diagnostic Tests (RDTs)

Metric	Mean	SD
Microscopy	1.3	0.4
RDT	1.2	0.3

The table provides a comparison of two diagnostic methods, namely microscopy and rapid diagnostic tests (RDTs), based on their mean values and standard deviations. These metrics are commonly used to assess the accuracy and precision of diagnostic tools.

The first metric, "Microscopy," represents the performance of the microscopy-based diagnostic method. The mean value for this method is 1.3, indicating that, on average, the microscopy diagnostic yielded a result of 1.3 for the parameter being measured. Additionally, the standard deviation (SD) of 0.4 reflects the spread of the data points around the mean. A smaller SD suggests that the results tend to cluster closely around the mean, indicating higher precision and consistency in the microscopy-based diagnostic measurements.

The second metric, "RDT," represents the performance of the rapid diagnostic tests. The mean value for this method is 1.2, which means that, on average, the RDT diagnostic resulted in a value of 1.2 for the parameter. The standard deviation (SD) of 0.3 indicates the variability of the RDT results around the mean value. A smaller SD suggests that the RDT results are more consistent and tightly clustered around the mean, signifying better precision.

Discussion

The presented demographic profile provides valuable insights into the characteristics of the specific population under study. The mean age of 25 years and the standard deviation of 10 years suggest a moderate age variability around the average. Similar studies have observed age distributions with comparable mean and standard deviation values, indicating that this population may represent a relatively diverse age group [6].

Regarding gender representation, the almost equal distribution of males and females with 52% and 48%, respectively, aligns with previous findings in other populations, showing a balanced gender ratio [7]. The occupational distribution reveals that students, farmers, laborers, and others comprise significant proportions of the population. This breakdown corresponds with studies in similar settings, highlighting common occupations and providing valuable context for understanding the population's economic activities [8].

The data on social-economic status, with approximately 30% classified as low, 40% as medium, and 30% as high, reflects a diverse socio-economic composition. Studies in comparable populations have reported similar distributions, underscoring the importance of addressing the needs of different socio-economic strata [9]. Switching to the blood parameter analysis, the mean hemoglobin concentration of 10.4 g/dL and standard deviation of 2.2 g/dL are consistent with normal ranges observed in healthy populations [10]. The mean hematocrit of 31.2% and its standard deviation of

4.4% align with expected values in previous studies on blood composition ^[11].

Regarding the red blood cell count, the mean of 4.2 million/ μ L and standard deviation of 0.8 million/ μ L are within the range of values typically observed in healthy individuals ^[12]. Similarly, the mean reticulocyte count of 3.2% and its standard deviation of 0.8% are consistent with findings from previous research on reticulocyte levels ^[13]. Lastly, the comparison of microscopy and RDT diagnostic methods shows that both yield similar mean values for the parameter being measured. The smaller standard deviations for both methods suggest relatively high precision and consistency in their results ^[14].

In conclusion, the results provide valuable insights into the demographic characteristics, blood parameters, and diagnostic performance of a specific population. This information can be used to tailor specific interventions or policies to address the needs of this population, and to improve the accuracy and precision of diagnostic tools.

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